

# Production versus conservation in New Zealand and German beech forest management - a modeller's perspective

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## Abstract

In Bavaria, Germany and in the South Island of New Zealand indigenous beech forests comprise large landscape units. In Germany almost all of this forest is under silvicultural management, nature conservation being of only secondary concern. The reverse is true for NZ beech forests. The two attitudes of managing beech, one which attempts to integrate conservational concern into multi-purpose silviculture and the other in which the two management goals are segregated to different land areas represent different belief systems and paradigms with respect to the valuation of ecosystems. Seen from within forestry, the differences in valuation and belief appear as external and cannot be put to empirical test or consistency constraints.

Here I suggest that a more comprehensive classification scheme based on modelling assumptions rather than on utilization goals offers a better way to clarify such valuation conflicts. In one modelling paradigm of ecosystems predictive tasks are selected as focal points and in the other evaluative tasks of management act as focal points. Between these extremes it is possible to map the positions that become publicly expressed about the issues of conservation and timber use. In this classification scheme Bavaria and NZ in the past represented two very different attitudes, but were consistent with their respective environmental and cultural histories. Recently Bavaria seems to follow the NZ example and in a sense is switching between extremes. This change puts the continuation of Bavarian silvicultural culture and competence at risk.

## Introduction

Temperate beech forests became widespread in Germany (consisting of one species *Fagus sylvatica*) and were already widespread in New Zealand (consisting of few species of *Nothofagus* (Wardle 1984)) at the time when farming and pastoral cultures spread into these landscapes and transformed them (Küster 1995). In Central Europe the human induced transformation started about 7000 years ago and in New Zealand less than 700 years ago. A number of domesticated species migrating with farming cultures were involved in both cases, transforming New Zealand agricultural ecosystems into a Neo-Europe (Crosby 1986). For the purpose of this paper I will stress the similarities among the native landscapes in Europe and New Zealand.

Across the world, species of *Fagus* and the related *Nothofagus* tend to dominate forests in which they occur. Older-aged forests of both genera have a similar structural appearance, usually with beech species dominating the canopy and with a relatively sparse subcanopy. However, each species represents a unique natural history and is part of a unique contemporary ecosystem. Setting the pre-agricultural landscapes of Central European beech and New Zealand beech as comparable is clearly a simplifying assumption. A modelling perspective, however, provides a mandate to do so. Pragmatically, the comparison is justified by the fact that both landscapes allowed for a similar set of farming and pastoral cultures to replace them. Here I use these similarities to serve as background highlighting extreme differences in the current management systems under which these remaining beech ecosystems are used in New Zealand and Germany, and the rationale to justify them.

In both countries forests comprise about one third of the land area. The current organisation of human

forest usage in both countries is, however, organised in markedly different ways. In New Zealand 30% of the land area is a conservation reserve, whereas in Germany only 0.6% is assigned to this goal. Some 84% of the remaining indigenous forest of New Zealand, in which beech has a large share, is included in this preserved area. Only 4.3% of the land is devoted to forestry utilising native species. The corresponding number in Germany is about 28%. This suggests that the attitude towards native forest species and especially beech dominated ecosystems is very different.

Not only the management systems of these forests differ, but also the institutions and the attitudes that became publicly expressed about forestry policies appear as strikingly different. Whereas in Germany managed beech stands are by and large perceived as 'natural' by the public, in New Zealand great scepticism has been expressed towards the deliberate human silvicultural interference in these ecosystems. In a commentary about the ecological impact of a proposed management scheme in NZ beech forests one reads: "While implementing the plans may retain a beech forest, ultimately its relative species composition and size class structure will reflect decisions made by Timberlands<sup>1</sup>. 'Improvement' felling to increase future timber yield will progressively turn natural forests into timber plantations akin to intensively manipulated European forests" (Sage 1998). The factual statement about European forestry is not controversial, but those parts of the statement made by Sage that relate to New Zealand are very controversial. The TWC<sup>1</sup> management plans were directed at maintaining structural diversity (& genetic diversity) as well as improving ecological processes adversely impacted on through pests such as possums and mustelids.

European beech forests have been manipulated for a long time by silvicultural schemes. These have changed

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<sup>1</sup> Timberlands West Coast Ltd (TWC), the forest company operating these forests.

the relative species composition and age class structure and may be able to implement societal goals of using the forests in a sustainable way. Whereas all these features are acceptable to the public in a German context, it is striking how the suggestion of such methods can (successfully, see below) be used as a detrimental scenario in the New Zealand debate. Apparently the underlying *value systems* for judging these systems are very different. How can these differences be interpreted or explained?

The aim of this study is to map the perspectives of forest ecosystems into a conceptual framework that is consistent for both cases. Silvicultural comparisons (Benecke 1996) and proposals for such frameworks have been made to assess the extreme segregation of preservation and utilization into different areas in New Zealand (Sands 2003; Perley 2003). These latter proposals have essentially been made from a one-dimensional forestry perspective. I will discuss below that such schemes are insufficient to include the German examples and that is why I introduce a more comprehensive scheme based on a general concept about ecosystem modelling and management. I will use only two case studies (one from each country) to exemplify the criteria and demonstrate typical results. Further tests, whether it is possible to accommodate the widely varying views and value systems with respect to forest ecosystems, will be left to the reader.

## Beech forest management in NZ exemplified by the Station Creek Forest

In New Zealand all indigenous forest ecosystems that occur on public land are managed by the Department of Conservation. 'Preservation ... for the purpose of maintaining their intrinsic value,' is the sole management goal (Conservation Act 1987). The 1993 amendment to the Forests Act 1949 requires any timber production from native forests<sup>2</sup> to ensure that the forests retain their diversity and natural stand structures in perpetuity<sup>3</sup>. This prescription includes the implicit assumption that such a potential of 'perpetual retaining' has been a 'natural feature' of these forests and may still be effective as long as deliberate interference by humans and exotic species are constrained. Such an assumption has currently little support from forest ecology (Kimmins 1992; Sands 2005).

The beech forest concerned had been managed since 1987 under the supervision of the Department of Conservation (DOC) when the former NZ Forest Service (NZFS: 1920-1987) was dismantled (Roche 1990). At that time the areas managed under the NZFS consisted of either plantations of exotic species (largely *Pinus radiata*) which were restructured as state-owned enterprises (SOEs) before, in many cases, privatisation, or of indigenous forests (6.4 M ha) which were transferred to DOC. Whereas management of the SOEs had timber production as its main goal, the goals

of DOC emphasised ecological protection and recreation.

From a conservation perspective in NZ the main management issue has been controlling or eradicating introduced mammalian pests such as mustelids, deer, rodents and the Australian brushtail possum, almost all introduced over the last 200 years or so of European contact. Many of the introduced species spread into indigenous ecosystems and altered them by direct competition with, and predation of, existing species, or through changing the conditions for others. In a regeneration study at Station Creek forests where the old beech canopy was opened within 5 years, 26% of the increasing herbaceous vegetation consisted of exotic species. This exotic vegetation may also attract and alter the browsing pressure by mammals to regenerating beech species (Wiser *et al.* 2005). The predisposition of NZ ecosystems to such exotic species invasions is derived from the peculiar (isolated) natural and cultural history of these islands. Today they are the only major land mass on which the number of exotic plants is larger than that of indigenous plants. The management aim in the 'protected' beech forests managed by DOC is to sustain the character of remaining indigenous forests as an almost 'virgin' land or as an unaltered 'wilderness' (Craig *et al.* 2000).

The distribution of forests in NZ today is the result of large clearances of indigenous beech and podocarp forests for farming and forestry both of which utilise domesticated species that have been introduced to NZ by Polynesian or European settlers (Roche 1990; Wynn 2002). No single endemic species has been domesticated for farming or forestry yet. The history of many NZ indigenous species since the advent of exotic species in the wake of human settlement is a history of extinctions. These often irreversible changes of the landscape form the background for the debates about the importance of timber production versus conservation goals. In these debates, (folk-) models of how ecosystems work and what values they have and provide become manifest and expressed. They may be incompatible with the scientific representation of the respective forest ecosystems.

Production forestry in NZ is largely based on pine plantations (*Pinus radiata*), managed in relatively short 25-30 year rotations with a clearfelling regime in which single coupes may reach up to one km<sup>2</sup>. Most of these forests are managed by few private timber companies, under strict economic scrutiny. Some 34% (by 2002) of these plantation forests are certified as sustainable under the FSC auditing system.

Recently all commercial logging has been banned from NZ-public native forests. The institutional segregation of production from 'conservation' is the result of several events, one of which will be used here as a case study. A state owned company (TWC)<sup>4</sup> based on the West Coast of the South Island, sought political approval in the late 1990s for a management plan in indigenous beech forests, including the Station Creek Forest (6800 ha). The plan

<sup>2</sup> Currently only allowed on private land.

<sup>3</sup> This goal may represent a 'normative fallacy' in the sense that it sets a norm without any basis in a natural science, but this question is outside the scope of this paper.

<sup>4</sup> Founded in 1987 as a state-owned enterprise (SOE) at the time of the disestablishment of the New Zealand Forest Service.

had been scientifically scrutinised as 'sustainable ecosystem management'. It was considered state of the art by the forest experts and much of the scientific community in forestry. It failed, however, to gain approval by the incoming government due to publicly expressed concerns about the long-term biodiversity and structural stability of indigenous forests. In addition, environmental groups had doubts about intentions and the competence of foresters to be able to handle these issues (Perley 1998). I will use this example to map the key attitudes that became expressed.

Changes in the goals of land management and the distribution of farming, pasture and forestry have been occurring throughout the NZ history (Roche 2002). They are likely to continue. Currently some pine plantations are being converted to dairy farming after harvest. The trading of CO<sub>2</sub> emission equivalents may alter the current economic margin between extensive pasture land and exotic forests again in favour of the latter. Even small changes in policy or markets may have large impacts in allocating land to different and new management goals. Plantation forests in New Zealand fulfil most (if not all) economic and ecological criteria of 'frontier agriculture' (Margolis 1977). Frontier farming consists of a system in which land is cheap and able to produce with relatively little capital investment for a volatile export market. All these aspects are almost the opposite of the corresponding framework of forestry in Central Europe. Land-locked areas such as Bavaria have high transport cost and historical timber production was mainly for a local market with a long-term perspective. I will now turn to the German case study.

### Beech forest management in Germany exemplified by the Ebrach Forest

The distribution of *Fagus sylvatica* (European Beech) covers a relatively small area of Europe compared to other main tree species. The centre of its distribution in the early Holocene was within Germany. That is why, from the perspective of conservation goals, a large share of the responsibility of conserving beech ecosystems rests there. On rich soils many of the beech forest have been cleared for farming. On the poorer soils beech forest has often been converted to other native species, mainly spruce (*Picea abies*) from the 19<sup>th</sup> century. These deliberate replacements were due to perceived or real economic circumstances. The values of these new plantings were subsequently reassessed when the risks involved became known and included in the economic assessment.

In some areas such as the Harz Mountains the transition from beech to spruce forests was occurring already in the 12<sup>th</sup> century and was in some areas almost completed by the 16<sup>th</sup> century. In the Harz this transition was driven by medieval mining. In the well-documented cases the property rights were settled from medieval times onwards and had only few changes afterwards. In Germany in general, few changes between forested and farmed land occurred after the 16<sup>th</sup> century. In the Hainich region a communal forest has been under the same ownership and management regime for centuries. It resulted in a rare example of a variant of

'Plenterforest' in beech. In this management regime, a small scale almost stationary distribution of all size classes is achieved, by a sophisticated and advanced single tree cutting scheme (Reiniger 2000). A less strictly regulated version of it is often termed continuous cover forestry (CCF). Recently parts of the Hainich forests were reassigned to a new national park.

Ebrach Forest, Steigerwald, is a beech forest located near Ebrach, Bavaria. The long-term stability in utilization and ownership is well documented. Bavaria is about half the size of the NZ South Island, but has 12 times as many inhabitants. The largest share of the forests is in public ownership, and the state alone owns 30%, or about 7 million ha, of managed forests with native species. This makes a comparable number to the 6.4 million ha indigenous forests in NZ assigned to preservation. In 2005 the administration of the Bavarian state forest was reorganised under mainly economic aspects, some of which resemble the ones from the dissolution of the NZFS in 1987. In both cases a core economic part of forest management was segregated from other tasks and given an enterprise structure. However, in the Bavarian case these forests were not sold into private ownership.

The Ebrach forest estate (prior to the reform about 5000 ha) consists mainly of mixed beech oak forests. It has become renowned for its silviculture regime putting particular emphasis on beech (Craig *et al.* 2000; Sperber 2004). It also hosts an experimental site, the Steinkreuz catchment, where ecosystem research commenced in 1993 (Matzner 2004). Today the forests can be regarded as a successful example of continuous cover forestry (CCF) in Germany. Its beech stands have been visited by many silvicultural excursions. Dr G. Sperber managed these forests from 1972-1998, among forest experts he is well-known as a representative of the Natural Forest Management Work Group in Germany (Arbeitsgemeinschaft Naturgemäße Waldwirtschaft, ANW).

At Ebrach a Cistercian monastery was founded in 1127. At that time it was among the first 36 Cistercian monasteries, and the first one in this part of Germany. By 1151 it had received and secured property rights over an area that is today known as the Ebrach Forest. From their foundation phase on Cistercian monasteries rapidly spread across Europe. The number of monasteries shows a logistic growth curve for the 12<sup>th</sup> and 13<sup>th</sup> centuries levelling off at about 700<sup>5</sup>. At this time the usage of agriculture ecosystems had changed and the monasteries were implicated in the spread of new technologies across Europe. Wherever they appeared they were soon donated land, to demonstrate the potential of these technological developments. Soon afterwards the number of cities in Europe shows a similar logistic growth curve, lagging 100-200 years behind the spread of monasteries.

The only other major land transformation matched by logistic growth curves in a relatively short time in Europe marks the period of industrialisation starting in the 19<sup>th</sup>

<sup>5</sup> The large-scale distribution of Cistercian monasteries quite closely resembles that of the European Beech (Downey 2002).



century. At Ebrach the corresponding changes in land tenure started with a change in ownership. The monastery was secularised in 1803 and its forest transferred to the newly founded Bavarian Forest Service. The transfer in 1803 was followed by a forest inventory, of which records have survived. A comparison of forests at Steinkreuz, the later site of the ecosystem study, in 1842 and in 1995 shows two mixed beech oak stands of about the same age (Fig. 1). Both stands are close to the rotation period for these stands of 130–150 years. The former stand was harvested soon after the 1842 inventory and natural regeneration started. Due to a relatively short period of successful natural regeneration (after 1848)<sup>6</sup> the stand today is still largely even-aged, despite 30 years of CCF.

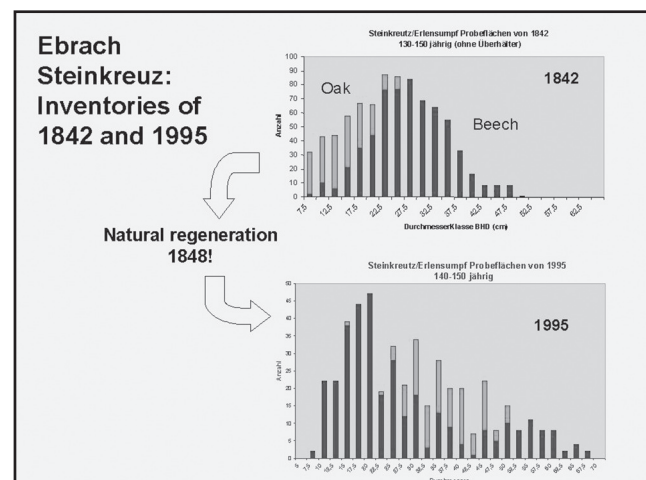
The 1842 inventory is accompanied by documents concerning the proper silvicultural treatment of beech and oak and the methods for natural regeneration. At that time oak was only present in the lower diameter classes, because bigger oaks had been sold or out-competed by beech. Oak trade down the river Main to Amsterdam was profitable during the 18<sup>th</sup> century and partly funded the baroque extensions of the Ebrach monastery. The silvicultural knowledge contained in the historic documents is of a high standard. It is very likely that local expertise from the time of the monastery management was still available for this assessment by the early Bavarian forest administration.

Today the diameter distribution reflects the silvicultural goals formulated in 1842. Then and today oak timber achieves a higher price than beech timber. In today's stand oak has remained present in the larger diameter classes due to repetitive thinnings from above and removal of competing beech. Beech dominates in this stand only where no oak trees were available. As beech grows faster at this site it occupies the larger diameter classes (Fig. 1).

Over time the percentage under beech had diminished in Bavaria in general as well as in Ebrach, though much less. In Bavaria beech forest covered 14% of the land area in 1972 compared to an estimated 85% in the pre-human Holocene situation (Sperber 2004). The motivation for a change back to a higher proportion of beech stands came at that time from within the Forest Service. The risks of spruce stands were re-evaluated. In addition the background of higher environmental awareness and the silvicultural freedom that a forester had at that time allowed other reasons to become decisive. Proponents in academia (e.g. Prof D. Mülner) and in the Forest Service (e.g. Dr Sperber) started campaigning for beech forests in the 1970s. Interestingly, the booklet by Mülner directly addressed the environmental 'grass root' movements of that time with arguments on how to increase the beech proportion within German forests. Apparently Mülner was sympathetic of such grass root engagement for nature conservation issues. This matches the later coalitions formed in Germany between environmental groups and silvicultural activists among Bavarian foresters.

<sup>6</sup> For a short period hunting rights were deregulated and peasants could hunt on their land. This resulted in sharp decline of browsing deer, and hence successful natural regeneration.

Fig. 1: Diameter distributions in mixed beech oak stands at Steinkreuz Ebrach in 1842 and 1995. Steinkreuz is the site of the ecosystem research projects.



In the 2005 Forest Service reorganisation, environmental interest groups campaigned for a referendum against the act, but failed with a small margin. The proposal for a referendum drew subscriptions from 9.3% (854,000) of the Bavarian voters (10% had been necessary). The reorganisation was implemented in June 2005, resulting in similar resentment among dedicated silviculturalists when compared to the corresponding 1987 reform in NZ (U. Benecke pers. comm.).

## Sketching the difference (first attempt)

These examples show that not only the assignment of land to management regimes was very different in Bavaria and New Zealand. The coalitions formed among the various interest groups were also different. In NZ the environmental groups formed a strange coalition with Treasury when the NZFS was ended – this 'suited the beliefs of two parties which, otherwise, had very little in common' (Perley 1998). In Bavaria corresponding environmental interest groups exist, but formed a coalition against Treasury in a similar rearrangement of forest management administration in support for the traditional forest management. Existing multi-purpose forestry as performed by the traditional management includes nature conservation goals as well as timber production. This was perceived by environmental groups as preferable to the economically streamlined organisation that took over. In both cases scientific institutions of forestry seemed to have acted as bystanders. The issues at conflict here are apparently dominated by world views (of ecosystems), values and ethics rather than by scientific argument. In the New Zealand case (Timberlands) this was afterwards lamented by many scientists.

Understanding can be gained by mapping the goals and values underlying these issues. New Zealand and German forestry were described as two extremes among possible forest management regimes. They were characterised as 'two radically different ways' in which the management intensities are arranged (Sands 2003). The representation by Volz (in Sands 2003 - Fig. 2) focuses at the goals of

management, questions of valuation are not addressed. The goals of complete nature protection and plantation monocultures form the opposite ends of management schemes. In the New Zealand regimes, private production forests and the protected indigenous forest under DOC represent the two extremes in this scheme. Germany is presented as a case of mixed intensity in which most forest management is placed in the middle of the diagram (Fig. 2).

The difference in the world views between interest groups of nature conservation and timber production is lost by such an interpretation. It does not accommodate the view of nature conservationists. From a forestry perspective the goals of timber utilization and nature conservation are miscible by appropriate schemes of silviculture. They appear as compatible. In this perspective the relative valuation of these goals as such is left to the political and economic arenas, while the valuation of any forest stand is a technical matter within silviculture.

From a nature conservation perspective, however, some proponents regard the values of goals as being incompatible in principle. Such groups will regard the goal of nature conservation as a *higher goal* resting on intrinsic values of natural ecosystems. They are opposed to any human interference, regardless of its intensity or technique (Sage 1998). In this perspective it is the human intervention itself which devalues the natural ecosystem almost irrespectively of the amount of timber extracted. What may seem a minor interference in the eyes of a forester, e.g. the difference between complete protection and a felling regime that takes much less than annual growth, may appear as a huge difference for a conservationist. In the latter view, as became politically successful in the NZ case, the remaining indigenous forests with their unique and exceptional natural history were promoted as having an intrinsic value that deserves protection against any (wilful) human alteration or utilisation.

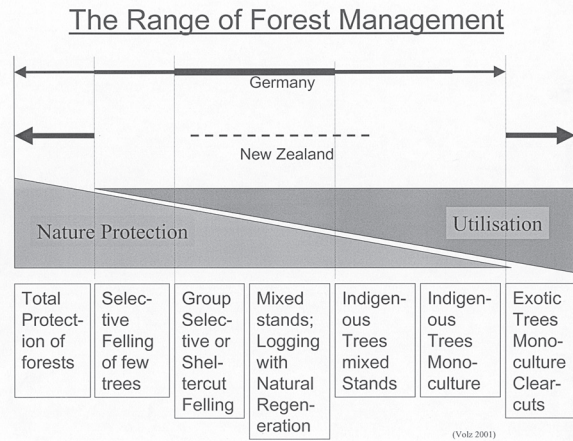
How can this conflict be analysed and settled? Is there any possibility to argue rationally about higher goals and values? Can they be put to consistency checks? From a forestry perspective (as expressed in Fig. 2) these issues inhabit an irrational outer world against which there can be no defence. This in fact seems (to the author) to be the rather bitter conclusion that most foresters have drawn from conflicts, which they regard as having lost in NZ and in Germany.

In the remaining part of this paper I will suggest a more general classification scheme, which includes issues of valuation, rather than externalising them. In addition the New Zealand and German cases appear as interesting under the generalised classification scheme as they provide in a nutshell examples of the contrasting perspectives in ecology and economy that beset many environmental issues.

### Models of Management Regimes

I consider nature conservation and timber production as two goals under which ecosystem management may become organised. The basic notions and dichotomy used

Fig. 2: Interpretation of the difference in management regimes (Volz - in Sands 2003). CCF stands for continuous cover forestry. What is analysed here are the goals of management. In NZ goals have become completely unmixed, and as a consequence the land area devoted to them. In Germany the goals remain mixed and hence silviculture requires a sophisticated integrated technique.



here for ecosystem management models are prediction and evaluation. Prediction will be made operational by the computational (algorithmic) effort necessary to derive the future states of the system just up to the predictive horizon, the point beyond which prediction is no better than guessing. Evaluation will be made operational by the documentation effort necessary to cover similar choice situations in the past and their respective outcomes in order to improve an actual choice beyond random guessing. Based on these two modelling paradigms management schemes can be derived, which will here be referred to as the *functional paradigm* and as the *interactive paradigm*. They represent the application of a corresponding modelling dichotomy (Hauhs & Lange 2006). Here I will only shortly characterise them before I apply them first to game theory and then to the case studies.

In the *functional management paradigm* one tries to avoid or trivialise any evaluation tasks involved. The tool to do this is prediction. Ideally the consequences of any action or event will be projected reliably into a situation where judging the outcome is easy. The daily weather report provides the archetypical example. It is based on a highly non-trivial prediction solving more than one million partial differential equations in parallel. Once we know it will be raining, we know what to do. Science is in charge of professionally organising the prediction task while the evaluation can be externalised and done by (almost) anybody. Under this first paradigm the default perception of an ecosystem (of the world) is as a system which one cannot intuitively understand, e.g. a chaotic system. Any order of such a system is invisible and has to be carefully uncovered by scientists.

In the *interactive management paradigm* one tries to avoid or trivialise any predictive tasks involved. The tool to do this is by proper evaluation standards. If the consequences of all possible actions in analogous past situations are

documented and memorised correctly within a group of experts, one can make a proper choice among the few options and their (short-term) predictable outcomes that are currently open. Raising children may be regarded as the archetypical example. It has to be based on experience and reliable long-term (non-trivial) prediction is elusive. Once we have been told what happened to others, we may get a clue what to try now. Science is implicated in professionally documenting and interpreting past outcomes, while the immediate prediction of what the actual options imply can be externalised and done by (almost) anybody. Under this second paradigm the default perception of an ecosystem (the world) is as an orderly system. However, chaos may lurk around the corner. Children may rebel and the order has to be actively maintained by adults.

The two paradigms imply two different principal limits, both of which have theoretical analogues in computer science. The first paradigm is limited by situations that are unpredictable because of algorithmically unsolvable tasks. In a chaotic atmosphere, predicting the weather more than a few days ahead, is impossible in principle. The second paradigm is limited by situations that contain unbounded choices and cannot be represented in a finite model of interaction. If parental experiences of former generations do not mention computer games, you have to make up your own experiences. In an open-ended cultural evolution evaluating choices is limited in principle by creative acts for which no useful norms exist yet.

## Examples from game theory

Before I apply the two management paradigms to the above cases in forestry, I will demonstrate the key ideas in a game example. The potentials, limits and differences of the two paradigms can be illustrated by two-person games, take chess and checkers (draughts). Both games have a clear goal. At any time all information is available to both players, no chance elements are involved, the legal moves at any time are few and simple with predictable (short-term) consequences. Any novice can learn them immediately. The difficulty and challenge in both games comes from the fact that it is very difficult for humans to choose a *good* move out of the few possible ones and of course from the fact that moves are strictly alternating between the two players. This task of evaluating a position and selecting one out of few alternative actions is what I will later use as an analogy with silvicultural decisions. There also the options are few (cut this tree out or not), irreversible, and the long-term consequence difficult to anticipate.

During the early era of digital computing, deterministic games were proposed as the major milestones for attempts of designing artificial intelligence. When would a computer be able to beat the best human player? Today no human can beat a computer in checkers, and very few humans may still be able to occasionally beat the best chess computer. Both milestones have been passed but, as will be discussed below, for very different reasons.

In the case of checkers the prediction tasks posed by the game were solved algorithmically by brute force

calculating the complete decision tree of the game. Once this was done a so-called 'winning-strategy' was identified. If white opens the game with its first draw and sticks to it, white will inevitably win, regardless of what its opponent does. At this point checkers ceases to be a game. After the opening move the winner is deterministically selected. This is the ultimate success of the functional management paradigm: a situation that appeared as interactive initially could be shown to be not. The challenging prediction is solved and can always be taken to the point where evaluation becomes trivial. Any intermediate position on a checkers board could be classified as winning or losing. An external observer of a checkers game in which one side is played by a computer may have the impression of a rather chaotically evolving game, but the underlying invisible order ensures that a computer playing white will always win. Humans may still enjoy playing against humans, because they cannot remember the winning strategy and may make errors, but this fun is based on ignorance.

In the case of chess the situation is (still) very different. No winning strategy has been found and it appears unlikely that this can be achieved in the near future. The combinatorial explosion of possible configurations a game may take is immensely larger in chess than in checkers. Such a winning strategy surely exists in an abstract mathematical (platonic) world. As long as our universe or especially our best computer is too small to calculate it, this is of no help for anyone who plays the game. The fact that computers today play at or above the level of the (human) world champion is based upon their increased *evaluation* competence. Thus chess is still, also for machines, an interactive game, in which an evaluation under time and computational constraints must be based on incomplete information. This has remained so even if today's computers are able to apply this evaluation upon a position 18 moves into the future. For a human agent engaged in a chess game any order is that of her own making, but chaos is around the corner, if she fails to note all the imminent dangers in the current position.

Training the machines, as training human players in chess, consists of improving their *evaluative* abilities. Of course this requires a lot of algorithmic computation, the qualitative difference between the two games resting in the way they are embedded into their environment. The overall game situation in chess up to today has remained interactive in a pragmatic or objective sense. If one has to face a chess game the option to improve one's own valuation competence is vastly more efficient than trying to improve predictive potential only and search for a winning strategy while not learning how to play at all. This is a typical case of modelling with resource constraints. A good player has to build up a lot of memorised and evaluated games. Valuation in chess is not imported from the outside world or by assigning intrinsic values to the pieces of the game, but has to be generated by experts communicating about the value of played-out and documented decisions in the light of their later outcomes. The decisive point is that all the training of proper decisions and access to cultural



memory of chess games can be accomplished by playing a computer. The computer does not solve the prediction task, but it serves a communication task in learning to evaluate the game.

These examples show that both paradigms occur and are applied today. The difficulty is to decide which one to use in any particular case. Many real-world situations have tasks that involve both, but any single task is either one or the other. In addition, the situation may change over time when new technology becomes available. For example, checkers was, some years ago, objectively interactive.

How do these examples map to the field of ecosystem utilisation? My hypothesis is, that behind the different opinions on how to utilise ecosystems stand different concepts about whether the human relationship to ecosystems is of an algorithmic/functional or an interactive nature. Unfortunately, in the case of forest ecosystems, science has done little to help classify situations into these types. Imagine a player to whom any game looks like checkers: hence there is an algorithmic strategy to solve any game. Evaluative task questions about values can ultimately be disregarded and left to the (irrational) external world. This position reminds us of the NZ-forester when managing exotic plantations. Imagine a player to whom any game looks like chess: hence a technical value can be assigned to any position and a best move identified by experience. Predictive tasks and rigorous scientific analysis can be disregarded and left to the external world. This position reminds us of the D-forester above. Can such suggested differences in management attitudes become scientifically decided? Which one is appropriate in the two cases?

### Application of two different management paradigms

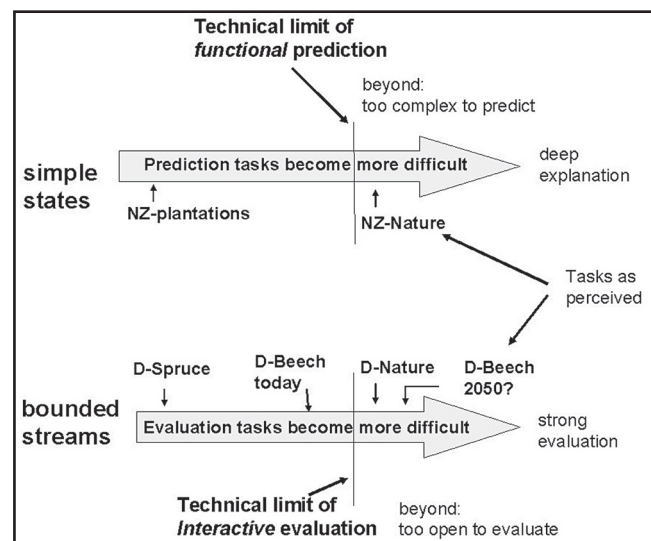
Forestry sciences have often been using the functional/algorithmic paradigm only and are thus presented in terms of solving a challenging prediction task for a complex system. In this perspective the interactive character of many advanced silvicultural regimes that were empirically developed in Central Europe have been difficult to accommodate (Benecke 1996).

The first book introducing the concept of sustainable forestry in Germany used the same language as used for raising children ('Naturmäßige Anweisung zur wilden Baum-Zucht') indicating the interactive character of the management tasks. The wide range of terminology that is still used today in this context demonstrates huge difficulties encountered when transferring these schemes under a consistent symbolic or functional representation (Gamborg & Larsen 2003). Such schemes, however, may profit from and become more easily documented in representations based on an interactive simulation (Hauhs *et al.* 2003).

Here I try to clarify these issues by comparing the functional and interactive management paradigms. I put the two management paradigms, functional and interactive, along two parallel axes, hence doubling the scheme of Volz (Fig. 3). The upper horizontal arrow resembles the classification proposed in Fig.2, however, now it becomes

expressed as the complexity of computational prediction tasks seen from the perspective of the forest manager. This interpretation reverses the scale relative to Fig. 2, the most complex (natural) stands appear now at the right. The lower arrow in Fig. 3 maps the number of parallel options open in an interactive management situation. The two arrows represent alternate ways to tackle a management problem in forestry. These predictive and evaluative tasks can be regarded as duals in the modelling paradigms (Hauhs & Lange 2006).

*Fig. 3: Comparison of predictive (upper) and interactive (lower) management paradigms. Along the upper functional paradigm the complexity of prediction tasks for the manager is indicated. It is a measure of the algorithmic effort up to the predictive horizon. Along the lower interactive paradigm the difficulty of choosing an option open to the manager is indicated. It is a measure of the documentation effort of similar choices and outcomes in the past. The vertical lines indicate the respective technical limits. Above the horizontal arrows are the positions of the various management tasks as they are perceived within their own culture in NZ and Germany(D). For example: D- and NZ-nature stands for 'Nature-conservation'. The D-Beech 2050 stands for a position sceptical to the present reform, in the respect that the current silvicultural competence will get lost in Germany.*



When prediction of a functional system becomes infeasible one may still assume that the world remains explained by similar models even beyond this limit (Fig. 3). This is the realm where reductionist convictions about the ultimately physical nature of the world become expressed, or in short where 'deep explanations' or theories of everything (TOE) are sought. A good indicator of these deep explanations is that they cannot be tested experimentally in principle and many different extrapolations, all consistent with testable theories, are possible (Hut *et al.* 2006).

When the representation of interactive choices becomes too large to be represented in a finite model one may still assume that the world remains regulated by similar norms and rituals even beyond the technical limit. In case of the above educational example: if no expert advice can be made on the basis of past experiences, the decisions can only be

based on good intentions (e.g. a professional norm of how to judge computer games educationally does not exist yet). The consistency constraint is that these intentions and adoption of absolute educational values remain compatible with the professional expertise that is already available.

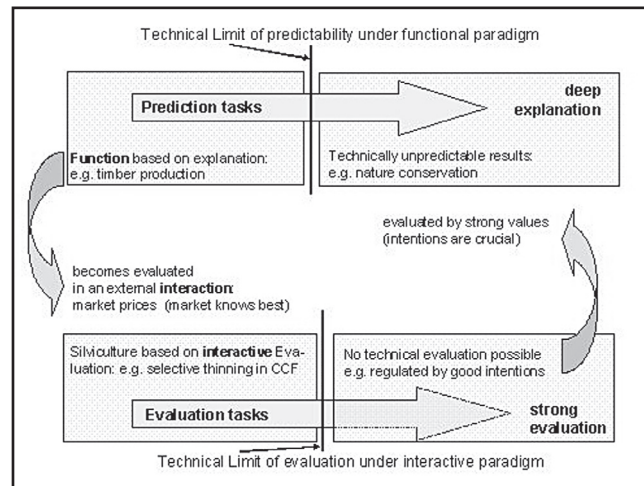
How can the two management paradigms become linked? As the examples have indicated, in the real world both cases may occur. Here I assume that in any single domain one of the two dominates, but the other may become embedded (Fig. 4). By embedding I mean that rituals within the interactive paradigm may become expressed as symbols in the functional paradigms (upward arrow, Fig. 4). Alternately, results of the functional paradigm may become expressed as rituals in the interactive paradigm (downward arrow Fig.4).

In the interactive, lower realm (of Figs. 3 and 4) 'holistic' convictions about intrinsic values, (e.g. of children, all living entities, etc.) become expressed, and 'strong evaluations' exist beyond the technical limit. A good indicator of such strong evaluations is whether they can be the basis of attitudes of admiration and contempt (Taylor 1985). Once beyond the limit, evaluations are likely to be based on 'universal motives' (and hence strong evaluations) other than trying to technically evaluate the system; e.g. religion, politics, greed, selfishness... An example from the above NZ case study is the unconditional intent of nature conservationists to protect indigenous forest (as carriers of strong intrinsic values) from incompatible (lower) intentions of humans who want to utilize such forests economically.

Forest ecosystems have often been described by ecologists as being among the most complex systems studied. This view is often expressed by nature conservationists, too. Currently it seems unlikely that humans will ever be able to predict such complex systems sufficiently as a prerequisite of controlling them such that evaluation of the results becomes trivial. For biologists the attitude towards living systems prescribed by natural sciences poses sometimes a dilemma. As scientists they need to disengage from these systems in order to work properly, however, their affection towards living systems has often much to do with the reason they have chosen their profession. The complex system attitude makes it possible to combine a professional view with a 'strong evaluation' of the living, e.g. (Wilson 1998). Thus scientist and nature conservationist may agree on the functional modelling paradigm as being appropriate for forest ecosystems and hence may project from the other realm by embedding living entities as carriers of strong values (upward arrow Fig. 4).

Ecology may work partly inside the complexity limit, but most working scientists may regard themselves far beyond the limit, studying systems too complex to be predicted. Typical attitudes of modern nature conservationists may be placed here as well. By the above projection they may express a 'strong evaluation' for systems beyond that limit of the prediction axis, rendering any evaluation tasks simple ('nature knows best', life has intrinsic values incompatible with any economic valuation etc.), especially as long as no decisions have to be made on how to technically implement

*Fig. 4: Possible mutual embeddings of the two management regimes of Fig. 3. A scientifically explained and predictable function may become evaluated within an interactive arena, e.g. the market (left arrow down). An open interaction among living agents (e.g. open biological evolution or social interaction) may become assigned an intrinsic value in the context of an unpredictable ecosystem (right arrow up).*



the higher goals of protection by human interference and management. That is why I place these positions beyond the technical limits (right upward arrow Fig. 4).

Plantation forestry with exotic species is relatively easy to handle silviculturally as long as these species remain free from pests and diseases. From a management perspective plantation forestry thus can be regarded as a much simplified prediction task. In New Zealand yield prediction at planting is easier than in most other management regimes especially with the short rotation periods possible. There is a slight anomaly here in as much as the predictive models used in plantation forestry are actually empirical in nature rather than 'process-based' or scientifically rigorous in terms of dynamic system theory. They are at best statistically rigorous. Under the modelling paradigm and the corresponding world view the situation known from meteorology should repeat itself here. Process-based models should be much more precise and efficient than empirical ones. This view has been often expressed in modelling, but to the dismay of its proponents has not occurred yet (Hauhs & Lange 2006).

For these plantation forests the value at harvest can be calculated by economic functions. 'Frontier farming' in general is an example for which the simple assumption of a 'homo economicus' has considerable explanatory power (Barbier 1997). For more complicated situations, but within the technical feasibility of prediction tasks (inside limit), valuation is not simply by resorting to absolute value systems (e.g. intrinsic values of the living), but by employing economic reasoning. From this one would expect a greater emphasis on issues of forest economy in NZ and a lesser emphasis on the silviculture of complex, indigenous forests. This is reflected in the NZ Forestry curriculum (Sands 2003).

The case of NZ forestry is still easily placed in this scheme (Fig. 3), with only the interpretation changed



from Fig. 2. In the reorganisation in 1987 and the ban on timber utilization from indigenous forests the NZ beech and plantation forests became segregated onto the two extreme sides of the 'prediction axis' removing any challenging silvicultural tasks from the forestry agenda.

The German silvicultural tradition is more properly described along the lower axis (Fig. 3 lower horizontal arrow) of increasing difficulties in evaluation tasks. In this perspective the basic attitude towards forests is how to sustain the documented and ongoing services provided by the ecosystem, rather than how to assess the state of an investment that went into the initial planting effort. This is relatively simple in even-aged mono-species spruce forests, more difficult in largely even-aged forests dominated by beech (Ebrach case) and even more for the Plenterwald or CCF systems. It may be beyond the current technical potential for many nature conservation tasks (Fig. 3, lower horizontal arrow).

The main silvicultural advantage of CCF may be that it offers more choice in each individual thinning and harvesting event, but also requires more evaluative competence to master it (Benecke 1996). Again, as in the other examples, immediate prediction of consequences is trivial (there will be a gap), and of the long-term consequences elusive (Fig. 3: lower horizontal arrow, but below technical limit).

That is why in New Zealand silviculture and nature management appear to be organised in a way resembling the checkers case above, whereas German foresters express attitudes resembling the more challenging game of chess. In this picture a new goal such as provided by nature conservation resets the whole evaluation tasks. Initially nothing can be judged, because the space of options and possible outcomes are too open (Fig. 3: horizontal arrow, but *beyond* the technical limit). By learning about successes and failures with past intervention schemes, nature conservation may come into a position similar to that of a forester practising CCF. An indication of this is that the evaluation tasks would in the future require high standards of expertise, rather than the absolute, indisputable values often expressed today by nature conservationists.

### Concluding thoughts

From a scientific point of view this reinterpretation has unexpected implications. It redefines the role of science for interactive scenarios. In a truly interactive situation such as encountered in CCF, relevant predictions are genuinely impossible. There will be no way to avoid initial failures and surprises. However, once the empirical results are in, science can assess the key elements and help to make dissemination of interpretations and learning among experts much easier. In these cases, modern information technology is supportive of communication tasks rather than predictive tasks. Flight simulators and chess computers are routine examples.

From this scheme it follows that New Zealand forestry is more closely aligned with modelling and management paradigms which are currently dominant in other sciences (including economics). The basis for this modelling paradigm is dynamic systems theory in physics. The

mechanistic and deterministic world views shared by the opponents of the beech utilisation for timber production (i.e. among nature conservationists and economic advisers) have been noted by Perley (2003). Both groups employ simple but 'strong evaluation' for systems they regard beyond the complexity limit (Fig. 3: upper horizontal arrow, above technical limit). They put their trust into self organisation of nature and the market, respectively, and hence could form a coalition. The projected strong values expressed by human intentions came into this issue (Fig. 4, right arrow up). The result is a division in land area with segregated management schemes as experienced by NZ in which any deliberate interactive aspect is removed (beech forests) or trivialised (exotic plantations).

In the NZ debate about beech forest management some of the environmental groups that expressed 'strong evaluations' with respect to the indigenous nature of the forests did not accept the scientific world view at all (Bigsby 1998). In fact, in the Timberlands case this science-sceptic view succeeded politically. Does the proposed scheme, other than classifying world views and modelling perspectives, offer a way of solving such principal evaluation conflicts? I think it does, but only in the long run. Beyond the technical limits nothing can be tested by definition, but it is still possible to check whether the extrapolations made across the limits are consistent with the forms of knowledge within them. As the physical theories of the world improved and the technical limit along the prediction axis moved, the deep explanations that remained inconsistent with them faced serious challenges and disappeared in most cultures. In a similar manner, it is to be expected that as the technical limits of the degree to which interactive expertise can be documented in virtual contexts moves with respect to ecosystems, the 'strong evaluation' schemes with respect of nature as such, will also become tested for consistency. It will become more difficult to impose ethical norms based on 'strong evaluation' that are inconsistent with managerial evidence up to the technical limit.

I have developed a scheme in which both values and goals of ecosystem management can be addressed in two consistent ways, represented by the two management regimes. Each of these schemes has its own criteria for consistent explanations and norms, for dealing with goals and values. The precondition of applying the scheme, however, is the ability of deciding which of two schemes is selected as the dominating one and which is embedded by projection. Are the differences in ecosystem management between Germany and New Zealand explained by natural or by cultural history? I will not answer this question here, but the proposed classification scheme suggested that such an answer might exist and may pose a constraint on future debates about the use of forests in both countries.

The two management paradigms are accompanied by typical default perceptions for the respective system. A natural ecosystem may appear as chaotic with a subtle underlying order, too hard to discover for scientists, but trusted by conservationists with good intentions (nature knows best). A silviculturally managed ecosystem may appear as orderly, in which the order is actively imposed

by competent human interference. The attitudes from the game examples reappear in environmental interest groups. The search for the most appropriate management system, however, can be posed within science if the goals are agreed upon. The adoption and valuation of an appropriate regime for such systems is not a question of fashion or taste. In the long run values assigned to ecosystems have to remain (become) compatible with the outcome of such rational choices about appropriate models of management options.

In the Timberlands case the practitioners and scientists of NZ forestry found themselves (in the losing) coalition on the high side of the complexity limit. In general NZ-forestry scientists remain close to leading scientific paradigms, but earn little public respect. A major anomaly, however, remains within this group; with respect to their practical prediction competence. Even in the case of simple *Pinus radiata* stands, where empirical prediction works well, this competence does not come from the sources where it should come from, i.e. a mechanistic understanding of growth process under the algorithmic modelling paradigm. This is an anomaly from a theoretical, scientific perspective only.

In Germany a split between timber production and nature conservation goals has not (yet) occurred for beech forest. In the Ebrach case Dr Sperber is respected for his achievements in silviculture as well as in nature conservation. Foresters are in general respected by the public, but often less so by scientists. From the proposed framework the split is indeed expected to occur between practitioners and scientists of forest ecosystems, especially those scientists that have their methodological background in the dominating modelling paradigm of natural science. It has been noted in Germany by administrators of science and by practical foresters how inefficient natural science has been, e.g. in resolving the forest decline issues, or substantiating sustainability in forestry (Keil 2004; Schanz 1996). From my analysis (Fig.3) such a gap may currently be inevitable. This situation will not change before interactive models and interactive situations achieve a more respected position in natural sciences. This would allow scientists to acknowledge that the interactive approach has its practical and theoretical merits.

From the perspective of the competing dynamic, functional model approach, any interaction has to be and can be avoided, because it ultimately rests on ignorance (i.e. of the true dynamic of the studied forest ecosystem or the winning strategy in the case of checkers). If, however, this ultimate knowledge remains at least technically unachievable, interaction might be by far the pragmatically more successful approach in forestry, but remains without scientific approval.

The forestry tradition in Germany (especially in those cycles that have been applied in CCF) seems to have implicitly taken this pragmatic interactive management approach to silviculture. Foresters in NZ, because of the discontinuity in ecosystem utilisation that is consistent with colonisation, had so far few chances of adopting this approach. In NZ Maori cultures may be more supportive of

this management style. As they own beech forests this is also where it may be legally developed. It requires a sophisticated form of cultural memory and a highly specialised context in which this memory can be communicated.

Two of the traditional contexts in which this has occurred are currently fading out in German forestry. For example, universities are changing chairs of silviculture into chairs of environmental ecology. In addition the Bavarian Forest Service is being streamlined under economic principles and constraints similar to those of the NZ 1987 reform. These may become a major obstacle for further survival of its silvicultural competence and frustration among dedicated practitioners seems endemic in Bavaria (U. Benecke pers. comm.).

On the other hand there is a largely unused technology available to document and disseminate silvicultural tradition outside its traditional homes in universities and forest administrations. Interactive computing is still a fast growing business and 'flight simulators for foresters' may some day become as common as those for pilots. When airlines compete for low fares on a free market the competence of their pilots is well ensured outside fierce competition. In the case of forestry the idea is to ensure sustainability outside the fierce timber market, but silvicultural competence of foresters may currently be largely under-valued. The changes in Bavaria appear thus as a move to a more stringent economic protocol in forestry as in other countries, while mimicking the context of their easy silvicultural tasks. The nature of the tasks and competence to be communicated may not be so different for pilots and foresters after all. Hopefully there is something left to be documented by the time the technology becomes fully available for foresters, too.

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